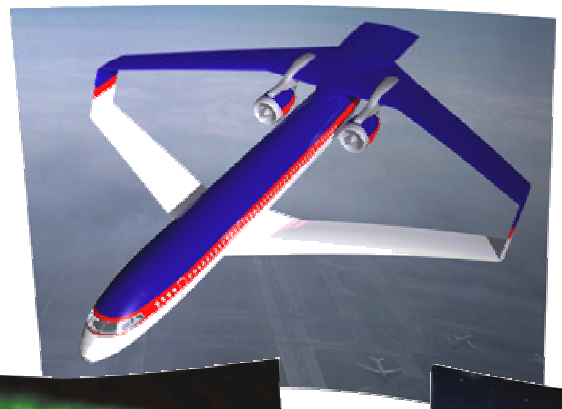
"To Extend Life to There"

Dr. Row Rogacki
Office of Aerospace Technology

March 25, 2003

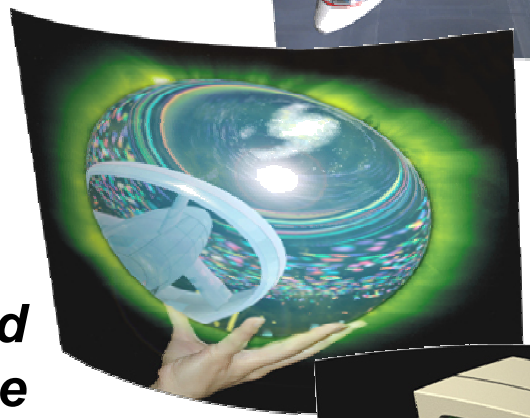
Aerospace Technology Enterprise Strategic Themes

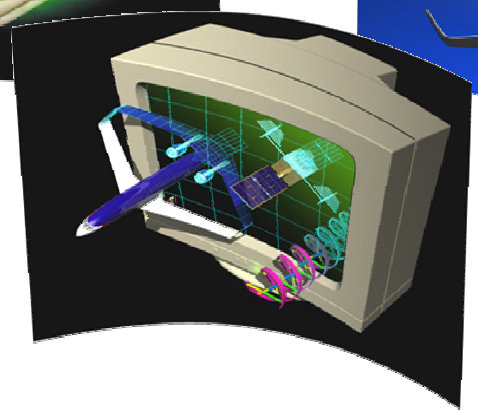
Aeronautics Technology



Space Launch Initiative

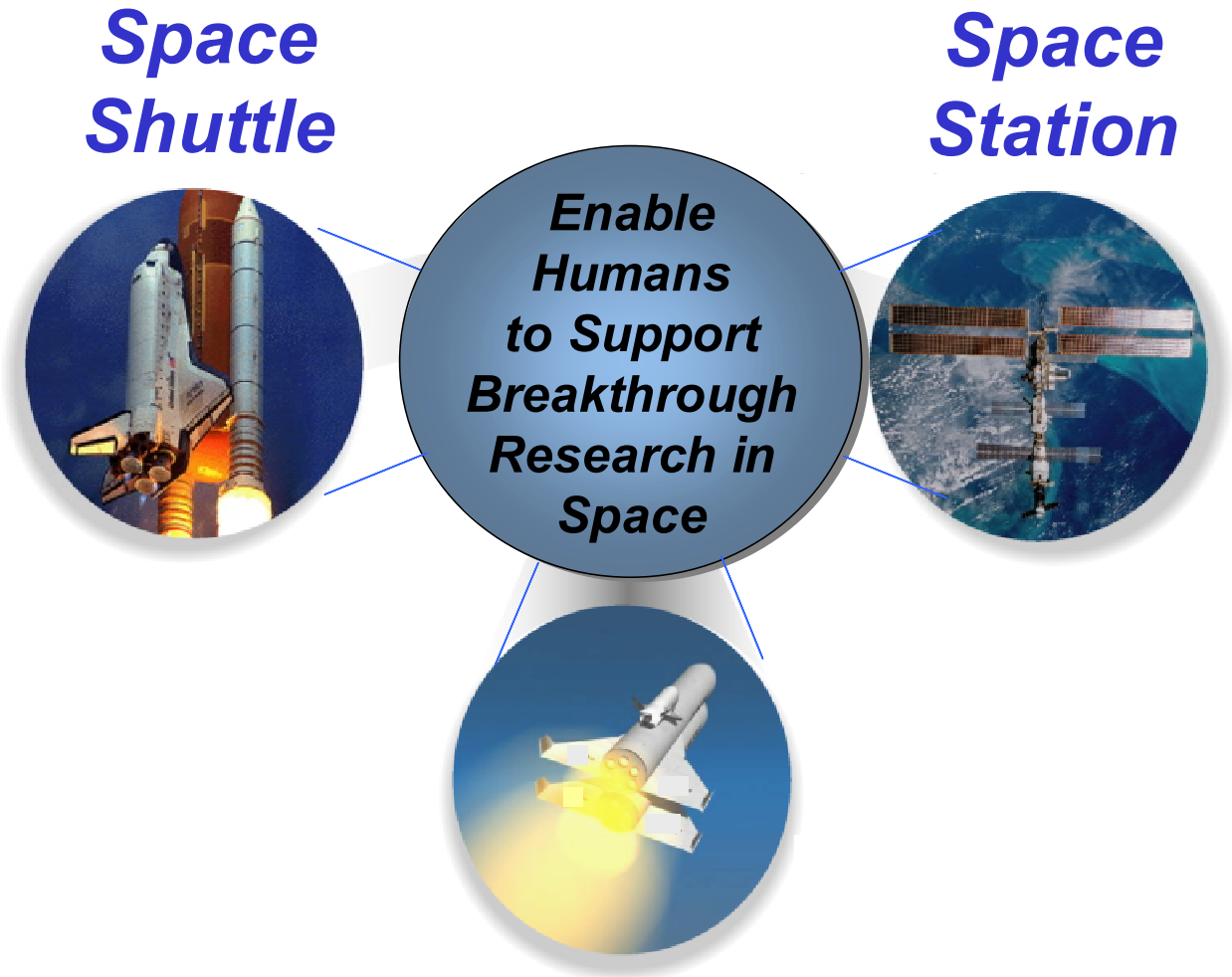
Mission and Science Measurement Technology





Innovative Technology Transfer Partnerships

Tight Coupling Among Research, Station, Shuttle & SLI



New Integrated Space Transportation Plan

Update: 10/24/02

02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22

International Space Station

US Core Complete

IP Core Complete

ISS Extend?

Future Exploration beyond LEO?

Space Shuttle

Competition Decisions

Operate Thru Mid Next Decade

Extend?

Extend Until 2020+

Further Extend as Crew and/or Cargo Vehicle?

Orbital Space Plane

Design

Orbital Tech Demo

FSD Decision

Development

ISS Crew Return Capable

Crew Transfer on Human-Rated EELV

OSP Primary Crew Vehicle?

Operations

Next Generation Launch Technology

Tech

Long-Term Technology Program

Launch System Decision (Based on Reqt, $, DoD)

Risk Reduction

FSD Decision

1st Flight

OSP Bridge To New Launcher

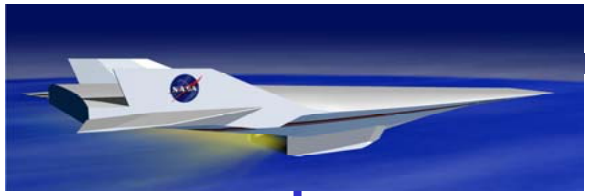
Hypersonic FSD?

Development

Operations

Space Launch Initiative
Program Management Structure

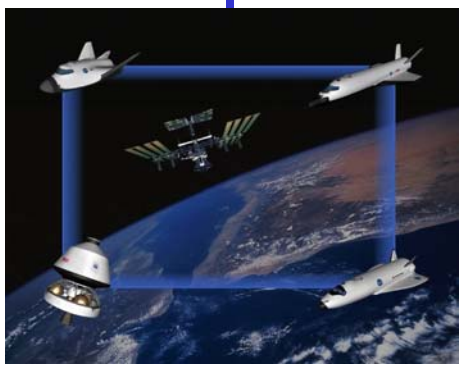
Office of Aerospace Technology



AA: Dr. J. F. Creedon

Space Transportation Technology Division

Director: Dr. Row Rogacki



Orbital Space Plane

Program Manager: Dennis Smith

Next Generation Launch Technology

Program Manager: Garry Lyles

Why OSPP Is Important

1. *Improve Safety*
2. *Assured Access to ISS*
3. *Address U.S. Crew Rescue Responsibilities*
4. *Bridge to the Future*

Orbital Space Plane Program Overview

Objective:

The vehicle(s) and associated systems will support U.S. ISS requirements for crew rescue, crew transport, and cargo.

- Provide rescue capability for no fewer than four ISS crew as soon as practical but no later than 2010.
- Provide transportation capability for no fewer than four crew to and from the ISS as soon as practical but no later than 2012.

Program Scope:

- **Technology and Demonstrations**
  - DART - Demonstration of Autonomous Rendezvous Technologies
  - X-37:
    - Approach & Landing Test Vehicle (ALTV)
    - Orbital Vehicle (OV)
  - Pad Abort Demonstrator (PAD)
- **Design, Development and Production**
  - Requirements Development and Validation
  - Vehicle Concept Definition/System Trades

Orbital Space Plane
MNS, Level 1 Requirements

Mission Needs Statement:

The vehicle(s) and associated systems will support U.S. ISS requirements for crew rescue, crew transport, and cargo.

Level 1 Requirements:

1. The system, which may include multiple vehicles, shall provide rescue* capability for no fewer than four ISS crew as soon as practical but no later than 2010.
2. The system shall provide rescue capability that allows the safe return of deconditioned, ill or injured crewmembers with ongoing treatment until arrival at definitive medical care within 24 hours. Crew should not require suits in the vehicle, but the vehicle should support crew wearing suits if the situation warrants.
3. The system for rescue shall provide for rapid separation from the ISS under emergency conditions followed by return to Earth.

**Rescue includes medical evacuation and emergency evacuation.*

Orbital Space Plane
Level 1 Requirements (cont.)

4. Safety requirements - system for crew rescue:
   a. The availability (defined as "a full-up vehicle able to perform its mission") for the escape mission shall be at least:

      Objective: 99%

      Minimum Threshold: 95%.

   b. The risk of loss of crew shall be, with high confidence, lower than the Soyuz for the rescue mission.

5. The system shall provide transportation capability for no fewer than four crew to and from the ISS as soon as practical but no later than 2012.

6. Safety requirement - system for crew transport: The risk of loss of crew shall be, with high confidence, lower than the Space Shuttle for the transport mission.

Orbital Space Plane
Level 1 Requirements (cont.)

7. The system shall be designed for minimum life cycle cost.
8. The system shall meet all applicable ISS requirements for visiting and attached vehicles.
9. Compared to the Space Shuttle, the system shall require less time to prepare and execute a mission and have increased launch probability.
10. Compared to the Space Shuttle, the system shall have increased on-orbit maneuverability.

Orbital Space Plane Concept Of Operations

1. The vehicle(s) shall initially launch on an ELV.
2. The system shall be operated through at least 2020. However, the system should be designed so that it could be operated for a longer time.
3. NASA envisions that the systems for crew rescue and crew transport could be different versions of the same vehicle design.
4. The system shall provide contingency capability for cargo delivery to or from the ISS to support a minimal level of science.
5. The system shall support a nominal ISS crew rotation period of 4-6 months.

X-37
Technologies Demonstrated

Flight Sciences
T-22 High Enthalpy Flight Profile**
T-39 Aero & Aerothermal Analysis

GN&C
T-13 Calculated Air Data System (CADS)**
T-17 All Weather Windward Adaptive Guidance**
T-26 Rapid Mission Data Loading**
T-29 Crosswind Landing**

Avionics/Software/Power
T-12 Open Architecture Avionics**
T-19 Fault Tolerant Autonomous Ops**
T-35 High-Energy/Density Batteries (Ion-Li)**
T-36 Electrical Actuation for aerosurfaces
T-37 Power Management & Distribution
T-38 Open Architecture Software

Propulsion
T-27 Low Cost Propulsion System (RCS)
AFT-2 Enhanced Attitude Control

Mechanical Systems
T-10 Lightweight Landing Gear**
T-31 Phase Change Brakes**

Ground/Flight Operations
T-21 Rapid TPS Waterproofing
T-28 Small Crew Flight Op. Control Center

Thermal Systems
T-3 High-Temp Windward TPS**
T-4 High-Temp Upper/Side TPS
T-7 High-Temp, Low Cost Joints/Seals**
T-9 Loop Heat Pipe TCS
T-33 Wing Leading Edge Tile
T-10 Durable Acreage Windward Tile
T-41 Durable Acreage Leeward Quilted Blankets
T-42 Durable Acreage Leeward Felted Blankets

Structures
T-6 High-Temp Gr/BMI Sandwich Structure**
T-8 Thin, Hot Aerosurfaces
T-32 High-Temp Gr/PETI-5 Structures**

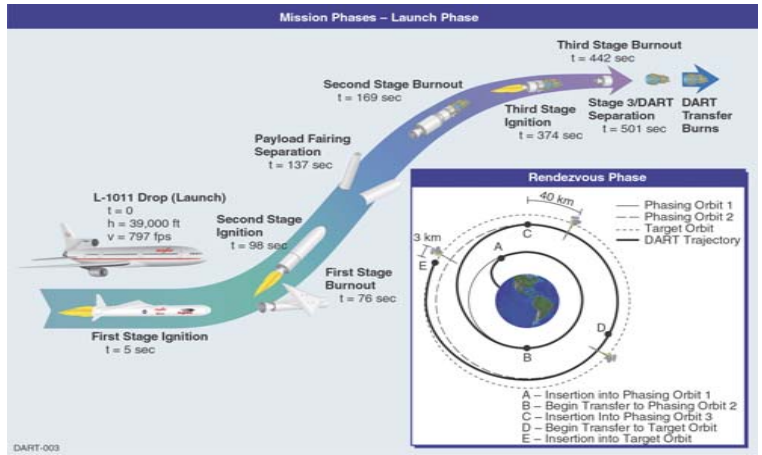
** ALTV & OV

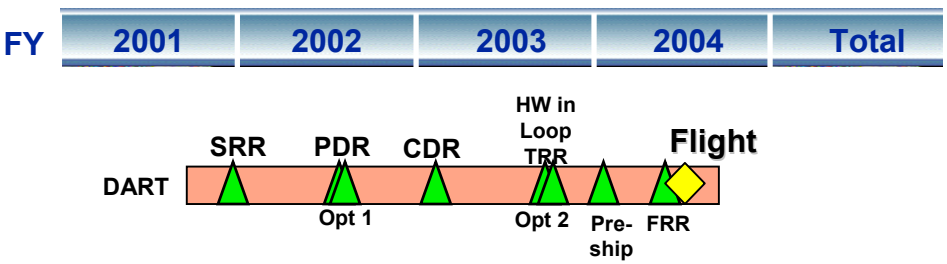
Orbital Space Plane DART

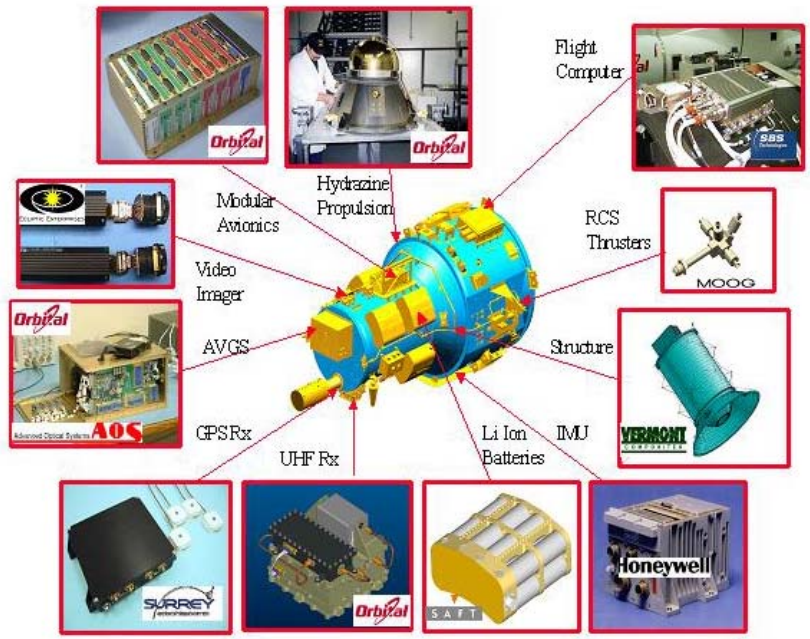
Demonstration of Autonomous Rendezvous Technology

- **Purpose:** Develop and demonstrate autonomous rendezvous and proximity operations (no pilot) between a chase vehicle (DART) and an on-orbit satellite
- **Status:** In manufacturing; effort continued from 2nd Gen RLV Program

- **Prime Contract:** Orbital Sciences Corporation
  - Option 1: April 2002 to May 2003
  - Option 2: June 2003 to June 2004

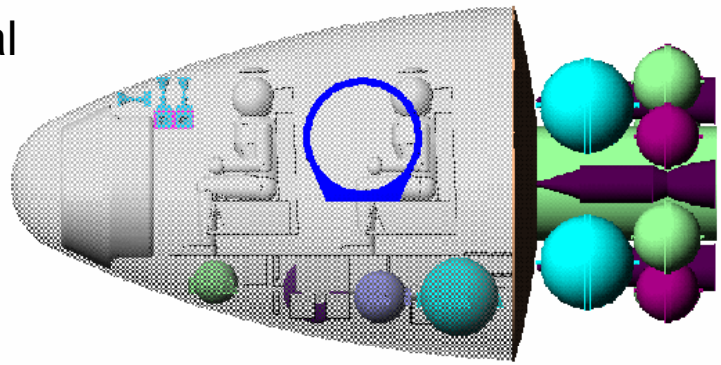




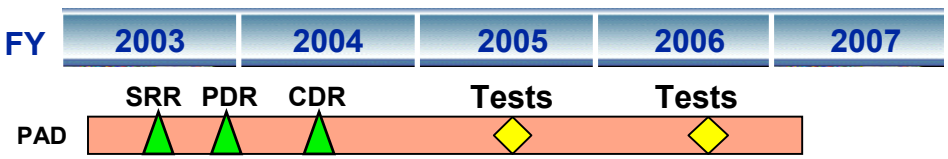


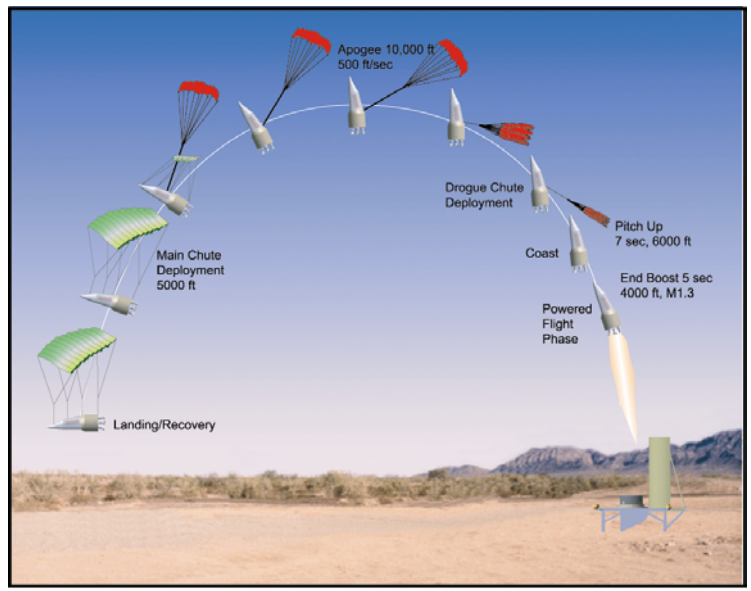
Orbital Space Plane
Pad Abort Demonstrator (PAD)

- **Purpose:** Provide full-scale platform for testing crew escape technologies to assess crew survival
- **Status:** In formulation; contract awarded as part of NRA 8-30 Cycle II



- **Prime Contract:** Lockheed-Martin
  - Base: January 2003 to February 2004
  - Option 1: March 2004 to November 2005
  - Option 2: December 2005 to November 2006





Next Generation Launch Technology Program Overview

Objective:

Develop technology to enable future space transportation systems to support NASA requirements in the coming decades.

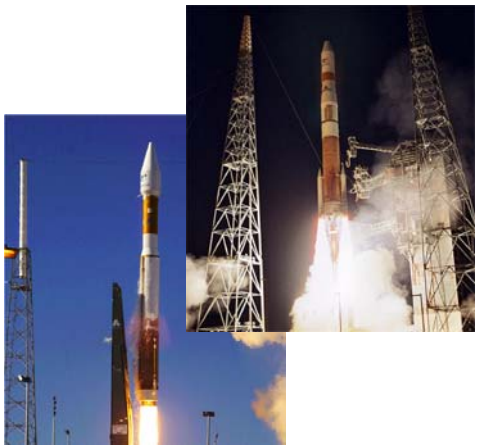
- Cutting edge research & technology investments
- Integrated with DoD through National Aerospace Initiative (NAI)

Program Scope:

- **Propulsion**
  - Rocket Engine
  - Air Breathing Hypersonics
- **Vehicle Systems**
  - Airframe including TPS
  - Integrated Vehicle Health
  - Operations
- **Flight Demonstrators**
  - X-43A
  - X-43C
- **Systems Engineering and Analysis**
  - Support investment decisions for future generations of Space Transportation Systems

Utilize an Integrated Technology Development Approach

Near and Mid Term Vehicle Concept Categories

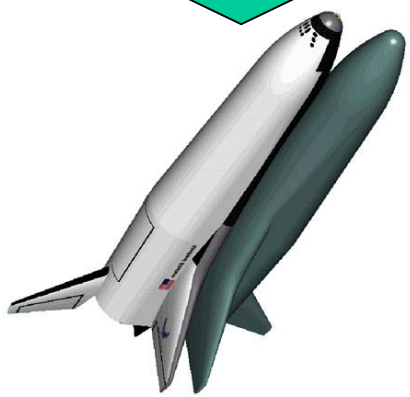


ELV Upgrades

Shuttle Life Extension & Evolved Shuttle

TSTO RP NASA

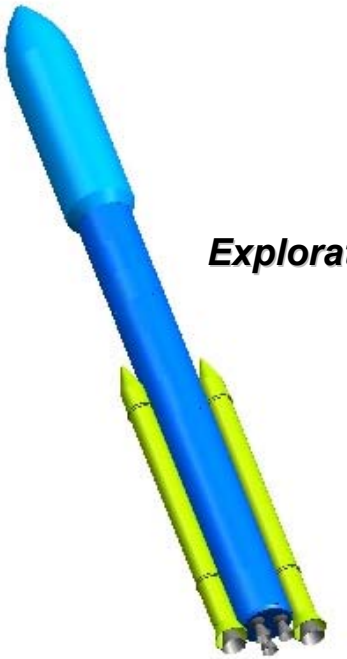
Potential Common Boost Stage



TSTO RP USAF

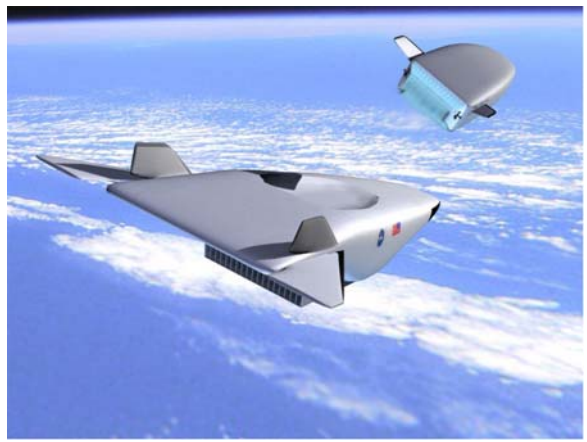
HTHL TSTO
Turbine/Rocket first stage
Rocket Second Stage

Longer Term Vehicle Concept Categories

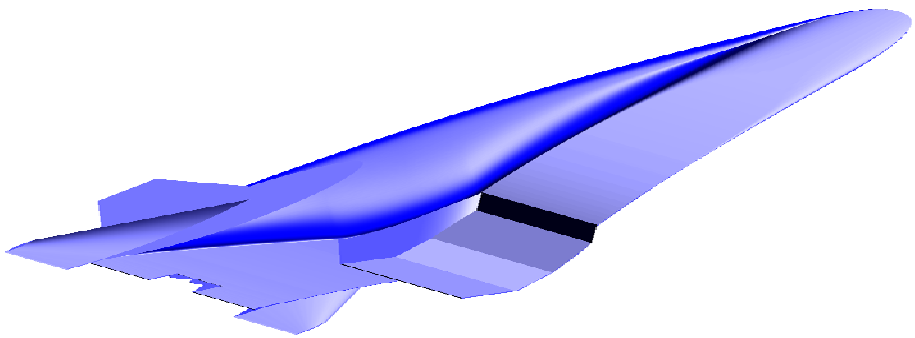


Exploration Heavy Lift

TSTO: Turbine Plus RBCC



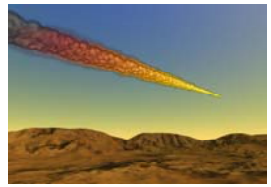
TSTO: RBCC



SSTO: RBCC and TBCC

Technology for Exploration Needs

Initial NGLT Assessment

NGLT Technologies	 Heavy Lift Launch	 Atmospheric Entry	 Ascent/Descent Stages
Rocket engine component and prototype development	●		●
Non-toxic auxiliary propulsion	●		●
Advanced, lightweight cryogenic tanks	●		●
Advanced composite structures	●	●	●
Durable, lightweight TPS		●	
Advanced Aerosciences (Flight Mechanics, Aerothermodynamics)	●	●	
NAll electricÓ subsystems	●		●
Integrated Vehicle Health Management	●	●	●
Low cost ground operations and range systems	●		
Systems analysis	●		

Approximately 60 – 65% of NGLT Investments Support Exploration Technology Needs

Technology Application to Shuttle Upgrades

Initial NGLT Assessment

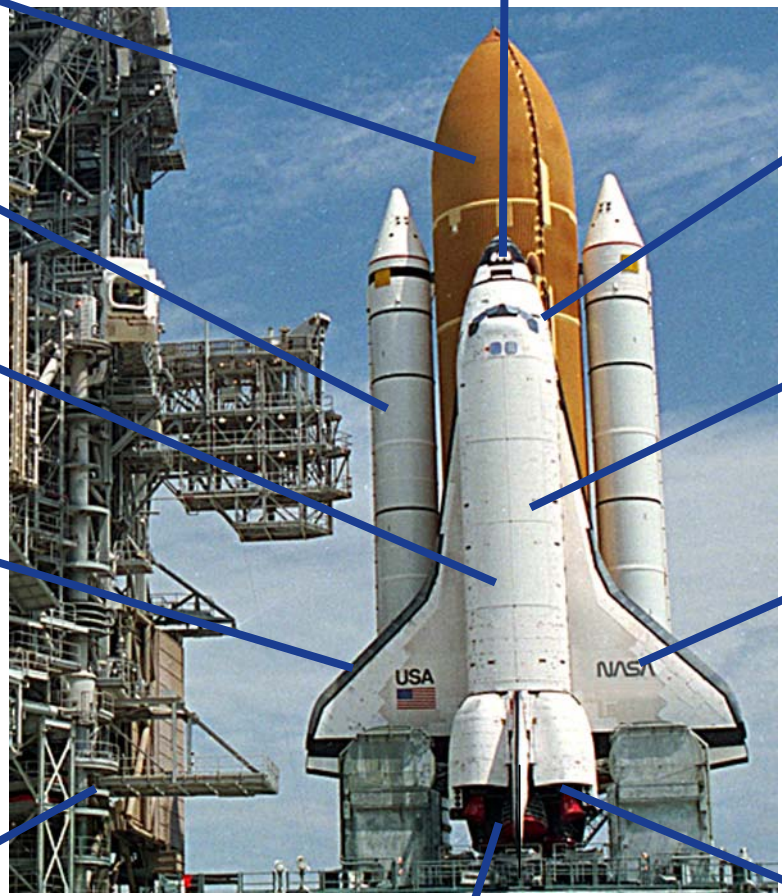
External Tank
- Self Reacting Friction Stir Welding
- Advanced Cryoinsulation

Booster
- LOx/RP liquid booster replacement (1+Mlb Prototype Engine)

Airframe Structure
- Ceramic Matrix Composite Control Surfaces
- Structural Health Monitoring Sensors

Thermal Protection Systems
- Light Weight, Intelligent Micrometeoroid Resistant Ceramic TPS
- Durable, Conformal Reusable Insulation
- Long Life, Durable Thermal Seals
- Rapid Waterproofing

Ground Operations
- Space Based Telemetry and Range Safety
- Silent Sentry/Passive Coherent Location (Advanced Range Technology)
- Range Architecture Development
- Advanced Umbilical Development
- Improved Propellant Management
- Densified Propellants
- Advanced Checkout Control and Maintenance System
- Launch Acoustic Environment Prediction



RCS/OMS
- LOx/Ethanol Dual-Thrust Level RCS Thrusters

IVHM System Integration
- Advanced Systems/Subsystems Diagnostic Algorithms
- IVHM/Flight Operations Integration

Subsystems
- High Horsepower, Electrically Driven Actuators
- PEM Fuel Cells
- Nontoxic Turbine Power Unit

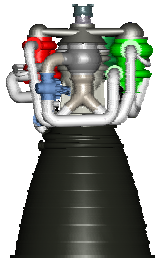
Aero & GN&C Tools
- Separation and Abort Scenarios
- Reentry Heating Environments
- Localized Heating
- Integrated Development and Operations System
- Integrated Aerothermal/TPS Sizing

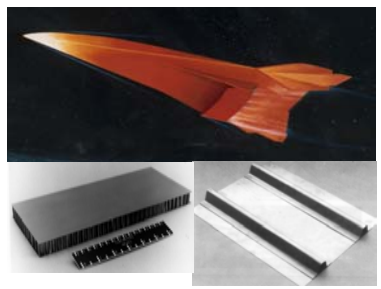
Aft Compartment
- Oxygen and Hydrogen Leak Detectors

SSME
- IPD Channel Wall Nozzle
- Advanced Turbomachinery
- GRCop-84 Main Combustion Chamber Liner
- Advanced Engine Health Management

NGLT is Enabling Many "Firsts" in Space Launch Technology

- 1st U.S. reusable kerosene-fueled rocket booster engine (1+ Million lb thrust). 1st reusable engine in 30 years.
- 1st U.S. demonstration of an oxygen rich staged combustion rocket engine cycle
- 1st controlled flight of a vehicle powered by a ram/ scramjet from Mach 5 - 7 and 10
- Fastest (Mach 4) turbine engine ever demonstrated
- Largest rocket based combined cycle engine system ever demonstrated
- High temperature/integrated airframes and composite cryogenic tanks
- Durable, intelligent thermal protection systems
- "All electric" launch system capable of managing system health
- Space based range launch tracking system to reduce costs and increase flexibility
- Training the next generation of engineers through sponsorship of 2 University Institutes (Univ. of Maryland & Florida) and 1 Consortium (Univ. of Alabama-Huntsville)





Summary

Orbital Space Plane:

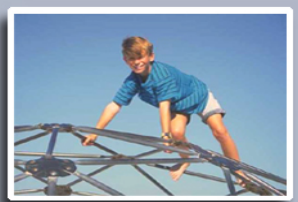
- **Level 1 Requirements established**
- **NASA/Industry team in place to proceed with Formulation Phase**
  - Conceptual design
  - Level II requirements
- **NASA/Industry team in place for flight demonstrators**
  - X-37 ALTV & DART demonstrations in FY04
- **Independent reviews planned to support Full Scale Development decision by end of FY04**

Next Generation Launch Technology:

- **Product oriented, cutting edge Research & Technology Program**
- **NASA/Industry teams in place for nearly all near-term efforts**
- **Integrated Technology Plan in development to guide future investment strategy**
  - Integrated with DoD and NASA Space Architect

Backup Material

Program Objectives Flowdown from NASA's Strategic Plan

Missions	Goals supported by this theme	Objectives supporting those goals (Reference 2003 Strategic Plan)
Understand and Protect Our Home Planet 	3. Create a more secure world and improve the quality of life by investing in technologies and collaborating with other agencies, industry, and academia.	3.1 Enhance the nation's security by developing and demonstrating critical access-to-space technologies that benefit NASA, DOD, and other governmental agencies. (NGLT)
Inspire the Next Generation of Explorers 	6. Inspire and motivate students to pursue careers in science, technology, engineering, and mathematics.	6.1 Improve student proficiency in science, technology, engineering, and mathematics (STEM) by creating a culture of achievement using educational programs, products and services based on NASA's unique missions, discoveries, and innovations. (NGLT, OSP)
	7. Engage the public in shaping and sharing the experience of exploration and discovery.	7.3 Increase public awareness and appreciation of the benefits made possible by NASA research and innovation in aerospace technology. (NGLT, OSP)
Space Flight Capabilities 	8. Ensure the provision of space access and improve it by increasing safety, reliability, and affordability.	8.1 Assure safe, affordable, and reliable U.S.-based crew access and return from the International Space Station. (OSP) 8.2 Make future space transportation systems safer, more affordable, and more reliable. (NGLT)
	9. Extend the duration and boundaries of human space flight to create new opportunities for exploration and discovery.	9.5 Develop innovative approaches and concepts to inform future decisions concerning systems, infrastructures, and missions for human and robotic exploration of space. (NGLT)

Commission on the Future of the United States Aerospace Industry

Recommendation #3:

"The Commission recommends that the United States create a space imperative. The *Department of Defense, the National Aeronautics and Space Administration and industry must partner* in innovative aerospace technologies, *especially in the areas of propulsion and power.*

Recommendation #4:

"The Commission recommends that the nation adopt a policy that invigorates and sustains the aerospace industrial base….*Sustaining critical technologies that are not likely to be sustained by the commercial sector, e.g. space launch*, solid boosters, etc."

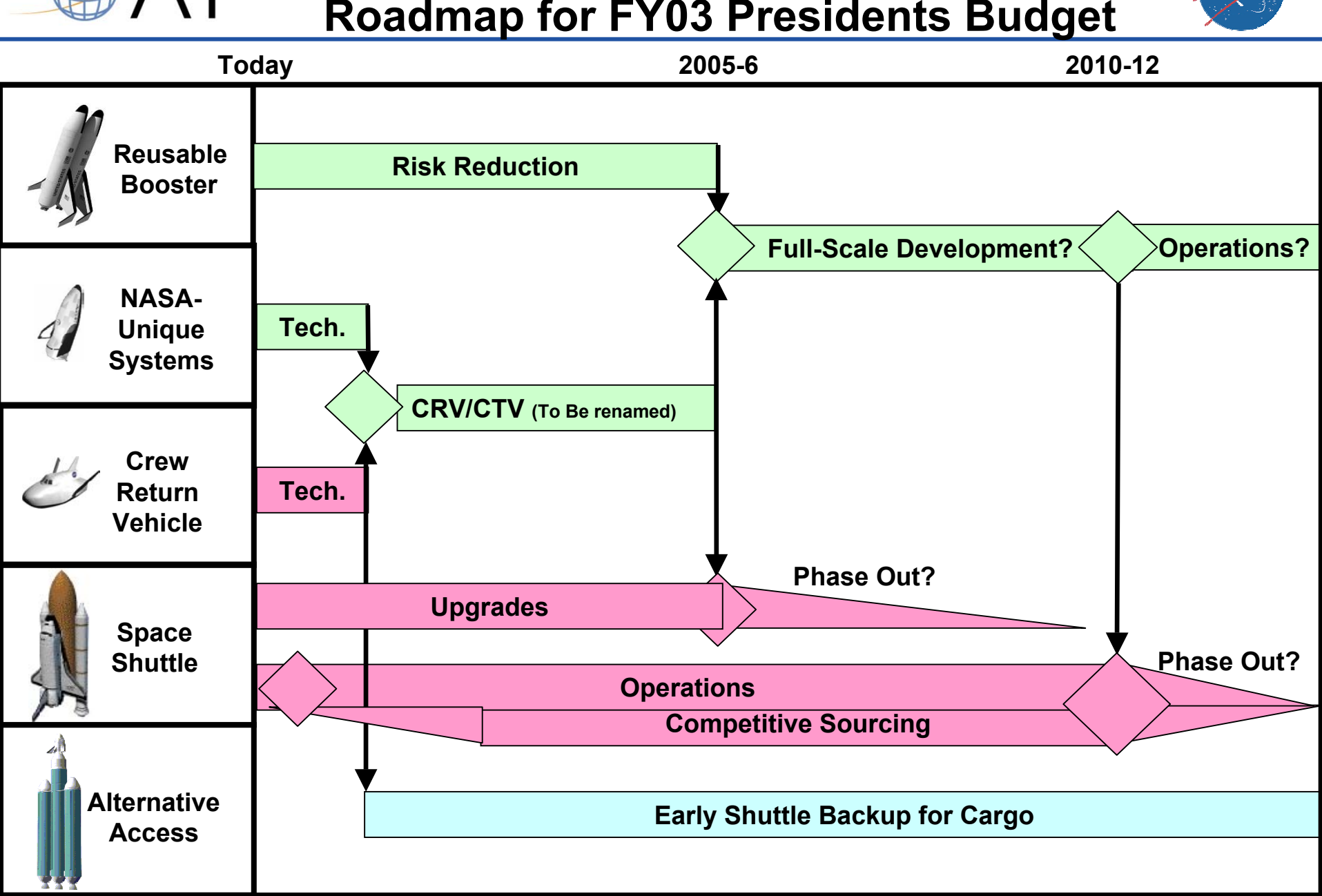
Recommendation #8:

"The Commission recommends the nation immediately *reverse the decline in, and promote the growth of, a scientifically and technologically trained U.S. aerospace workforce*. In addition, the nation must address the failure of the math, science and technology education of Americans."

Recommendation #9:

"The Commission recommends that the *federal government significantly increase its investment in basic aerospace research*, which enhances U.S. national security, enables breakthrough capabilities, and fosters an efficient, secure and safe aerospace transportation systems."

Integrated Space Transportation Plan
Roadmap for FY03 Presidents Budget



Programs Addressed by Budget Amendment

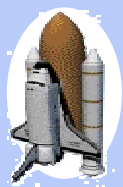
INTERNATIONAL SPACE STATION

SPACE STATION PROGRAM

BIOLOGICAL & PHYSICAL RESEARCH

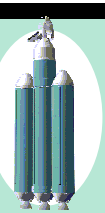
FY 2003 Budget Amendment

- Assures Core Complete
- Maintains Long-Lead Items for Potential Enhanced Research
- Maximizes Research
- Adds Launches
- Extends Operational Life
- Pursues Crew Transfer Capability
- Enables Future Launch Systems



Operations

Life Extension Program



Orbital Space Plane

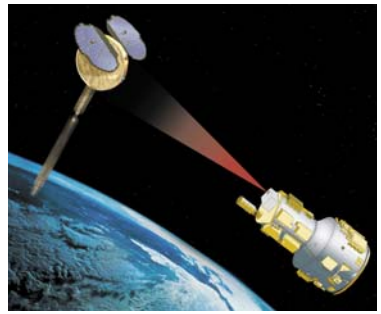
Next Generation Launch Technology

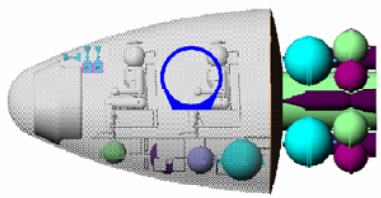
SPACE SHUTTLE

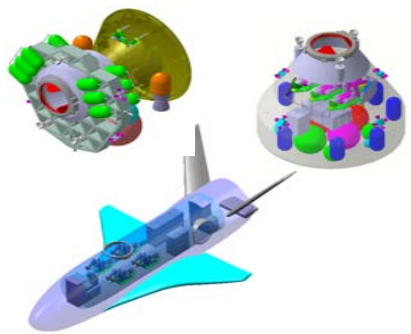
SPACE LAUNCH INITIATIVE

INTEGRATED SPACE TRANSPORTATION PLAN

Orbital Space Plane FY 2004 Highlights







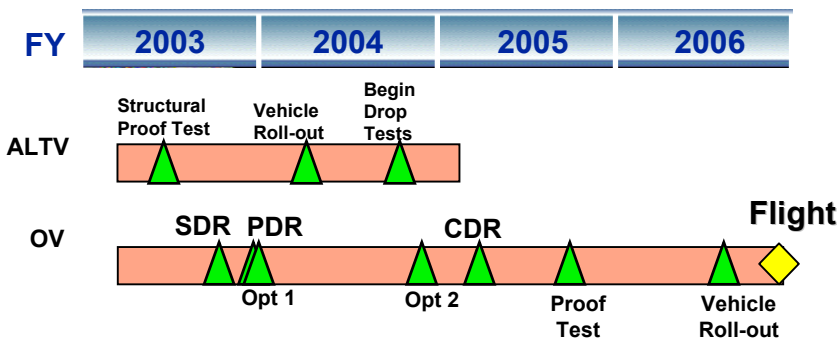
- Flight test of DART vehicle to demonstrate autonomous rendezvous technology between a chase vehicle and an on-orbit satellite
- Drop test of X-37 ALTV from a carrier aircraft to demonstrate autonomous landing capability
- Complete preliminary design of the X-37 Orbital Vehicle
- Complete final design of the Pad Abort Demonstrator
- Complete conceptual design of the Orbital Space Plane with sufficient cost, schedule, technical, and risk definition to enable a full-scale development decision

Orbital Space Plane
X-37

- **ALTV Purpose:** Validate autonomous operations (no pilot) and thermal effects during approach and landing (40,000 ft and below). Drop test from B-52.
- **ALTV Status:** In manufacturing; effort continued from 2nd Gen RLV Program

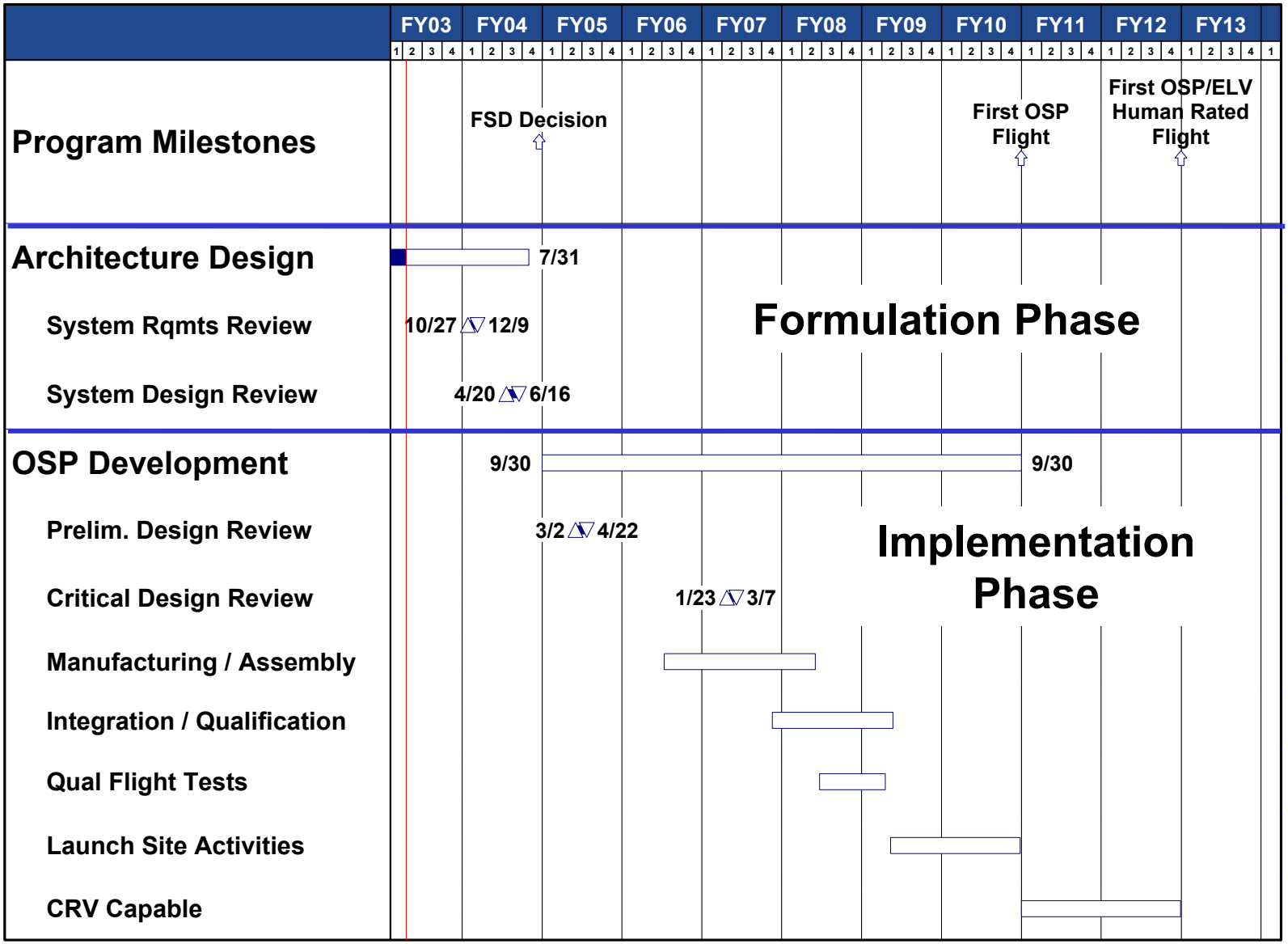
- **OV Purpose:** Provide versatile technology platform to validate critical technologies during ascent, on-orbit, and re-entry environments. Launched from ELV.
- **OV Status:** In formulation; contract awarded as part of NRA 8-30 Cycle II

- **Prime Contract:** Boeing. Consolidated contract covering ALTV & OV; Cooperative Agreement for ALTV closed out
  - Base: December 2002 to September 2003
  - Option 1: October 2003 to August 2004
  - Option 2: September 2004 to September 2006



OSP Top-Level Schedule

02/04/03



Preliminary ---- Not Baselined

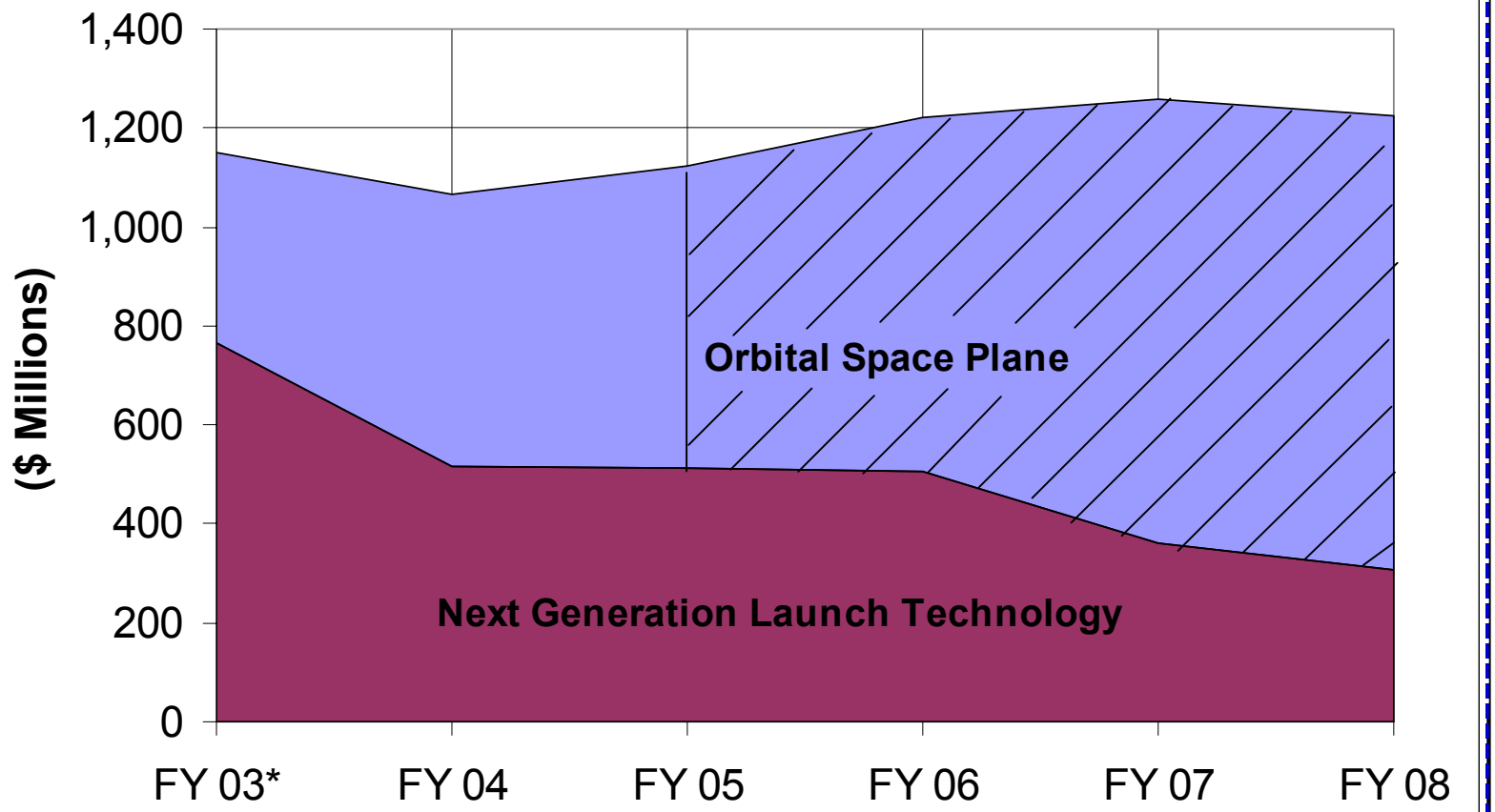
Gary L. Wentz, Jr / 256.544.6973

Orbital Space Plane Summary

- **Level 1 Requirements established**
- **NASA/Industry team in place to proceed with Formulation Phase**
  - Conceptual design
  - Level II requirements
- **NASA/Industry team in place for flight demonstrators**
  - X-37 ALTV & DART demonstrations in FY04
- **Full Scale Development decision by end of FY04**

Space Launch Initiative Budget

Space Launch Initiative Full Cost Budget



OSP Budget for Design, Development and Production for FY05 and beyond are placeholder estimates only

Space Launch Initiative	FY03 BAU	FY 03*	FY 04	FY 05	FY 06	FY 07	FY 08
Orbital Space Plane	295.7	383.3	550.1	609.9	716.6	894.7	916.0
Next Generation Launch Technology	583.7	767.1	514.5	513.8	504.7	362.3	307.4
Space Launch Initiative Total	879.4	1,150.4	1,064.6	1,123.7	1,221.3	1,257.0	1,223.4

*Note: FY 2003 reflects estimated Full Cost